The role of convective triggering in an AGCM

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Role of convective trigger

- Initialize (cumulus) convection
  - Determine the timing to occur convection

- Control instability of upper atmosphere
  - Affect condensation processes and precipitation

- Change the boundary layer condition
  - Moisten boundary layer
How to understand effect of triggering

1. Investigate the behavior of convection by using super-fine resolution model ($\square x \sim 100m$).
   - Environment of simulation is limited and global simulation cannot be performed.

2. Introduce conceptual triggering model into GCM’s (or mesoscale-model’s) convection parameterization.
   - The model expresses triggering process only qualitatively.

In this study, we are interested in role of convective triggering in global atmospheric phenomena.
Parameterization of convective trigger

- **Fine resolution model (1 km < Δx < 10 km)**
  - When parameterizing (cumulus) convection, we face the triggering process in the first place.
    - *In order to resolve the buoyant parcel which induces convection, horizontal resolution should be finer than several hundred meters.*

- **General circulation model (GCM)**
  - Convective parameterization for GCM represent the effect of several cumulus statistically.
  - Better parameterization should include statistical triggering effect.
    - *Each cumulus depends on convective triggering.*
Trigger function in this study

• Check the virtual potential temperature of source parcel at LCL (instead of LFC) by comparing it with environmental virtual potential temperature (Hong and Pan, 1998).

\[ q_{src} + \Delta q > q_{env} \]

\( \Delta q \): perturbation of virtual potential temperature

• Definition of source layer
  – Source layer has largest moist static energy between surface and 400 hPa above the surface
Mechanisms perturbing virtual potential temperature

- **Surface inhomogeneities**
  (constant value)
- **Turbulence-induced buoyancy**
  \[ q_{cbl} = b \left( \frac{w_s}{w_s} \right)_0 \]
- **Convergence (divergence) in source layer**
  \[ q = \left[ 1 + c_4 x \left( \frac{\partial n}{\partial p} \right)^{1/3} \right] \]
- **Updraft at the head of gust front**
  \[ q_{gst} = a \left( \frac{\partial W_g}{\partial Z_h} \right)^{1/2} \]

The sub-grid feature of gust front is **prognosed** according to the model of Qian et al. (1998)
Convective triggering in GCM

- Simulation was performed by CCSR/NIES AGCM with the resolution of T106L20
  - The triggering function was implemented into prognostic Arakawa–Schubert scheme.
  - Large scale condensation is described by Le-Treut and Li scheme.
Time-longitude diagrams of filtered velocity potential at 150 hPa

**Observation**

- **No trigger** (10°N–10°S)
  - Time-longitude diagrams of filtered velocity potential at 150 hPa
  - Observation
  - Year

- **Trigger (inhomog.)**
  - Time-longitude diagrams of filtered velocity potential at 150 hPa
  - Trigger

- **Trigger (inhomog.+conv.)**
  - Time-longitude diagrams of filtered velocity potential at 150 hPa
  - Trigger

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**Note:** The images show time-longitude diagrams with varying color scales and annotations indicating the filtered velocity potential at 150 hPa, with observations and triggers indicated for different regions (10°N–10°S).
Trigger (inhomog.)

Frequency of permitting convection (10°N–10°S)

Warm pool

Indonesian

L.S.C. rain / total rain (10°N–10°S)
**Trigger (inhomog.)**

**Cumulus+L.S.C. heating rate**
(100°E–150°E, 10°N–10°S)

1 year

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**Trigger (inhomog.+conv.)**

**Cumulus+L.S.C. heating rate**
(160°E–170°W, 10°N–10°S)
Trigger (inhomog.)

Cumulus heating rate (160°E–170°W, 10°N–10°S)

L.S.C. heating rate (160°E–170°W, 10°N–10°S)

Trigger (inhomog.+conv.)

L.S.C. heating rate (160°E–170°W, 10°N–10°S)
Summary and toward the future

• To simulate atmospheric phenomena more realistically in GCM, we should introduce appropriate triggering processes.

• Current triggering model is very conceptual. We need more realistic triggering parameterization.

• Better triggering parameterizations
  – have the dependence of model resolution,
  – change the strength of triggering by region and time according to obvious physical mechanisms,
  – include less tuning parameters.

• We should investigate convective triggering using super-fine-resolution model under various conditions.